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GERMINATION AND SURVIVAL OF JACK PINE AND RED PINE AFTER SCARIFICATION IN SOUTHEASTERN MANITOBA

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Germination and Survival of Jack Pine and Red Pine after Scarification in Southeastern Manitoba

BY

J. H. CAYFORD[1]

INTRODUCTION

Although extensive areas in the southeastern corner of Manitoba support pure jack pine stands, red pine is in some instances associated with the jack pine.[2] One of the major problems involved in management of the mixed pine stands is that of securing adequate regeneration following logging.

In 1954 an experiment was initiated to determine whether scarification of the forest floor following the removal of merchantable jack pine from mixed pine stands would be an effective technique for inducing pine regeneration. Examination of regeneration on both scarified and unscarified areas was carried out annually between 1955 and 1958.

DESCRIPTION OF EXPERIMENTAL AREAS

The experimental areas, which are located in the Rainy River Section of the Great Lakes-St. Lawrence Forest Region (Rowe, 1959), were logged during the winters of 1952-53 and 1953-54 under the supervision of the Manitoba Forest Service. All merchantable jack pine were removed and the slash was lopped and scattered. After logging the areas supported a very open residual stand of red pine interspersed with patches of young jack pine. The ages of the red pine varied from 40 to 70 years, their diameters from 4 to 12 inches, and dominant trees averaged 45 to 50 feet in height. Table 1 presents an average residual stand table after logging, and Figures 1 and 2 show views of the residual stand on two of the blocks.

TABLE 1.—RESIDUAL STAND TABLE PER ACRE AFTER LOGGING
(No. of trees)

Species	d.b.h. (inches)												Total
	1	2	3	4	5	6	7	8	9	10	11	12	
Jack pine.....	16	1	3	3	1	1	1	1	1				28
Red pine.....				1	1	2	2	1	2	2	3	3	17

Advance growth on the experimental area was sparse and consisted of scattered jack pine, red pine, and white spruce.[3] There were 100 jack pine stems and 67 white spruce stems per acre. The number of red pine was unknown as they were removed for transplanting purposes prior to scarification.

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[2] For a list of botanical names of all species mentioned in the text, see Appendix.

[3] Advance growth was considered to be all stems, less than one-half inch in diameter at breast height, which had become established before logging.

FIGURE 1. Residual stand on Block "B". This block averages nine red pine trees per acre. Note sparseness of the crown cover.

The physiographic site may be classified as 4:1:0 (Hills, 1952) indicating that the ecoclimate is normal for the region, the moisture regime is dry, and drainage is extremely rapid. A typical soil profile for the experimental areas is as follows:—

A_{00} —0 to 1 inch; pine needles; herbaceous and shrubby leaves.

A_0-A_1—1 inch to 2.5 inches; black[4]; pH 5.3 to 5.6; organic matter mixed with course sand and a small amount of loamy material.

A_2 —2.5 to 6 inches; pale brown; pH 5.6; weakly developed horizon; medium sand.

A_2-B_1—6 to 7 inches; transition from A_2 to B_1 horizons.

B_1 —7 to 14 inches; yellowish brown; pH 5.7; somewhat compacted, medium sand; scattered limestone pebbles.

B_2 —14 to 20 inches; yellowish brown; pH 6.4; structureless, coarse sand; very scattered granitic pebbles.

C_1 —20 to 25 inches; brown; pH 8.0; structureless, coarse sand; calcareous; scattered limestone pebbles.

C_2 —25 to 29 inches; dark brown; pH 8.0; gravel with limestone and granite pebbles; calcareous.

C_3 —29+ inches; pale brown to light grey; pH 8.2; structureless, fine sand; calcareous.

The areas are characterized by level topography. Minor vegetation is profuse with shrubs and medium-tall herbs the dominant strata. Grasses and low herbs are also present. Predominant species include bearberry, redroot, strawberry, saskatoon, rose, spike oat, mountain-rice, choke-cherry and sand-cherry.

[4] Soil colours were determined from a Munsell colour chart.

FIGURE 2. Residual stand on Block "C". Red pine averages 30 trees per acre.

METHODS

In July of 1954 three blocks varying in size from 0.8 acre to 3.1 acres were established on the cut-over areas. On each block six-foot-wide strips, spaced approximately 12 feet apart, were scarified in groups of six using a tractor-drawn Athens plough. Scarification was carried out in two stages; the strips were cleared of slash with the bulldozer blade and scarification was then completed using the plough. Scarification resulted in complete exposure of mineral soil and burying of the organic layers. Scarified strips were characterized by a series of furrows and ridges (Figure 4); the former were up to six inches in depth and usually sloping.

FIGURE 3. General view of Block "A" showing shrub layer of vegetation on an unscarified area.

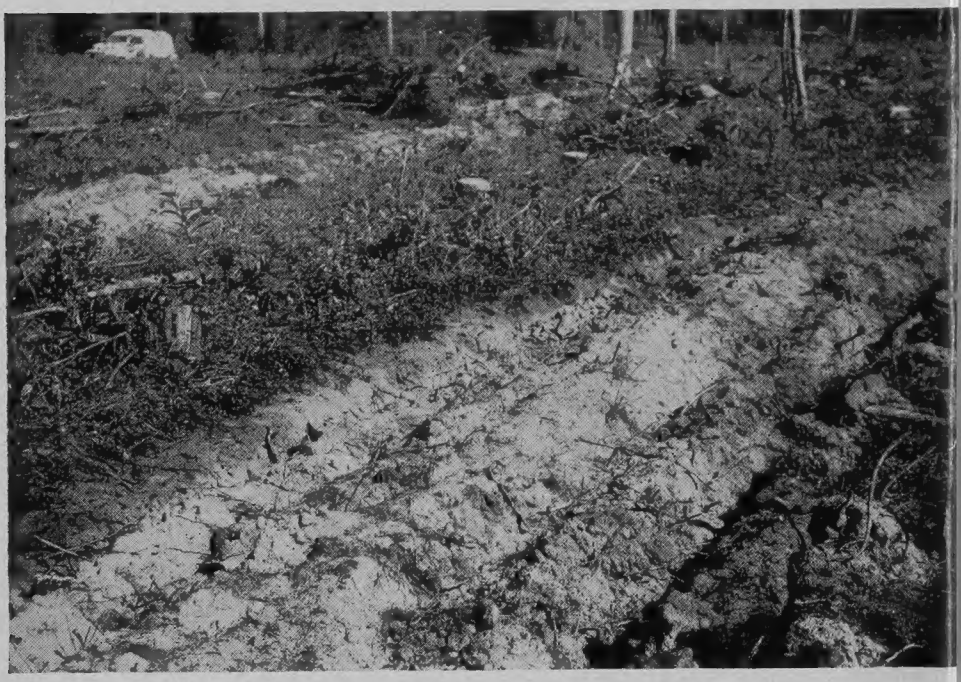

FIGURE 4. Scarified strips immediately after scarification, 1954.

In 1954 both the residual stand and the advance growth were tallied on the experimental blocks. In 1955, 696 circular plots, each 1/4,000-acre in size, were established on the cut-over areas. One half were located on scarified areas, the other half on unscarified areas. These were examined annually from 1955 to 1958, and were recorded as stocked or not-stocked with pine[5]. In addition, a complete seedling tally was made on every third plot.

RESULTS

The results of the four regeneration examinations are presented in Tables 2 and 3. These tables include all seedlings which germinated after cutting or scarification; jack pine and red pine seedlings are grouped together.

TABLE 2.—PER CENT STOCKING OF PINE ON SCARIFIED AND UNSCARIFIED AREAS

Block	Scarified areas				Basis No. of 1/4,000-acre plots	Unscarified areas				Basis No. of 1/4,000-acre plots
	1955	1956	1957	1958		1955	1956	1957	1958	
A	23.7	9.6	12.8	5.8	155–156(1)	2.5	1.3	1.9	0.6	154–156
B	14.1	6.7	6.7	5.5	89–120	0.8	0	0	0	77–120
C	18.1	8.3	2.8	2.8	72	5.5	1.4	1.5	0	66–72
All blocks	19.2	8.3	8.8	4.4	317–348	2.6	0.9	1.3	0.3	298–348
All blocks	57.4	28.9	30.4	16.6	Conversion to a one-milacre basis(2)	9.8	3.6	5.2	1.2	Conversion to a one-milacre basis

(1) Variation in number of plots examined was due to some plots being destroyed between the examinations.

(2) Stocking conversion to a one-milacre basis was made using Grant's (1951) formula, assuming random seedling distribution. By using Gill's (1950) heterogeneity index it was found that the seedling distribution closely approached randomness.

TABLE 3.—NUMBER OF PINE SEEDLINGS PER ACRE ON SCARIFIED AND UNSCARIFIED AREAS

Block	Scarified areas				Basis No. of 1/4,000-acre plots	Unscarified areas				Basis No. of 1/4,000-acre plots
	1955	1956	1957	1958		1955	1956	1957	1958	
A	1538	615	700	307	52	308	77	231	77	52
B	800	400	286	250	28–40	0	0	0	0	25–40
C	500	500	167	167	24	0	0	0	0	22–24
All blocks	1069	518	461	269	104–116	138	35	120	40	99–116

The 1958 per cent stocking, although low, was 15 times higher on scarified than on unscarified seedbeds. Also, scarified areas had an average of 269 seedlings per acre in 1958 as compared with 40 on unscarified areas. The majority of seedlings on the scarified seedbeds were observed either in the bottom of the furrows or on their sloping sides. A few were observed on level ground and on the tops of the ridges.

[5] A plot was considered stocked if one or more seedlings were present.

FIGURE 5. Scarified strips four years after scarification, 1958.

Although most new seedlings were observed in 1955, the first year after scarification, some were found in 1956 and 1957, indicating that at least portions of the scarified areas were receptive to seed germination three years after scarification. By 1958, grass had become quite dense on the scarified areas and no new germinants were found. Figures 4 and 5 show views of scarified strips immediately after scarification in 1954, and four years after scarification, respectively.

Germination

To determine the effectiveness of scarification as a method of inducing pine germination, any plot which had one or more seedlings on it during any one of the four examinations was considered stocked. The results of this analysis are given in Table 4. It is apparent that scarification was very beneficial for germination.

TABLE 4. -PER CENT OF PLOTS STOCKED DURING AT LEAST ONE REGENERATION EXAMINATION
(Basis—one-quarter and one milacre plots*)

Block	Scarified areas		Unscarified areas	
	One-quarter milacre plots	One milacre plots	One-quarter milacre plots	One milacre plots
A	34.8	81.8	5.1	19.3
B	19.1	57.2	1.3	5.2
C	22.2	63.4	7.6	26.8
All blocks	27.6	72.6	4.7	17.8

* Stocking conversion to a one-milacre basis was made using Grant's (1951) formula.

Survival

Table 5, based on combined data from the three experimental blocks, shows the number of seedlings, by year of germination, which were tallied annually on the scarified areas. No information is presented for unscarified areas because such a very small number of seedlings occurred on them.

TABLE 5.—SURVIVAL OF PINE SEEDLINGS ON SCARIFIED AREAS

Year of seedling germination	Number of living seedlings tallied annually			
	1955	1956	1957	1958
1955	31	8	5	5
1956	—	7	1	0
1957	—	—	6	2
1958	—	—	—	0

Seedling survival has been very poor on the scarified areas. Maximum mortality occurred during the first year after germination, usually within the first month. There was also high mortality on unscarified ground, and there was no apparent difference in seedling survival between scarified and unscarified areas.

DISCUSSION

Although scarification did not result in successful regeneration of the cut-over areas, it did produce a marked increase in germination. However, a very high rate of seedling mortality offset most of the benefits of scarification.

Table 4 indicates that 27.6 per cent of the scarified one-quarter-milacre plots were stocked during at least one examination, and this is equivalent to 72.6 per cent stocking by milacre plots. An area with this stocking is considered to be well stocked by Candy (1951),[6] and had seedling survival been higher, scarification could have been a successful technique for securing an adequately stocked stand on the cut-over areas.

Many factors combined to produce conditions which were very unfavourable for seedling survival. Local environment was inimical to survival and the dryness of the site is indicated by the extremely rapid soil drainage and the coarse sandy soil. Maximum heights of red pine on the site are only 50 feet, considerably less than those on the better sites in Manitoba. The minor vegetation community, and in particular the abundance of bearberry and redroot, provides further evidence of dry moisture conditions.

The residual tree cover was very sparse, averaging only 45 stems per acre, 20 of which were jack pine with breast height diameters of less than four inches. Consequently, this cover provided very little shade and protection for the seedlings.

The climate of southeastern Manitoba is characterized by cold dry winters, hot summers, and low annual precipitation. Average annual precipitation at Winnipeg, approximately 60 miles west of the experimental area, is 21 inches, and although it is mainly distributed during the summer months, high temperatures often create moisture deficiencies in the area. During the period of observation, 1955 to 1958, climatic conditions were variable. The summer of 1955 was extremely dry and drought conditions prevailed in August and early September.

[6] Candy considers a stocking of between 60 and 79 per cent, on the basis of milacre plots, as moderate stocking.

During 1956 and 1957 temperature and precipitation conditions were close to normal. 1958 was characterized by below-normal precipitation and average temperatures.

The dry site, the sparse residual tree cover, and the regional climate are all factors which combined to produce very hot and dry soil conditions. Between August 22 and 29, 1958, soil surface temperatures of between 120°F and 150°F occurred, even though the maximum temperature recorded at Winnipeg during this period was only 77°F. It is evident that high soil surface temperatures and drought conditions have caused considerable mortality of seedlings on the experimental blocks.

As there is no practical field method of distinguishing between young red and jack pine seedlings, no attempt was made to differentiate between them. However, in 1957 it was observed that of five surviving 1955 seedlings, two were red pine and three were jack pine. There is considerable evidence to indicate that the majority of the 1956 and 1957 seedlings were red pine. First, red pine seed was available in the residual stand whereas jack pine seed, because of the few stems per acre and the serotinous nature of the cones, was not. Most of the available jack pine seed would have been lopped and scattered between 1952 and 1954, and cleared with a bulldozer blade before scarification. Secondly, the seedlings were not usually found beside open jack pine cones. Thirdly, most of the new seedlings had either six or seven cotyledons and observations in Manitoba and at the Petawawa Forest Experiment Station[7] indicate that most jack pine have four cotyledons, a few have five or more, whereas red pine usually have six or more.

SILVICULTURAL IMPLICATIONS

The results of the experiment indicate that if scarification is to be successful under the field conditions of this experiment, seedling survival must be increased. Two possible courses of action are indicated depending upon which species of pine is to be favoured in the regeneration.

If red pine is desired the severity of the cut should be reduced in order to increase the crown cover and provide additional shade for the seedlings. The beneficial effect of a crown cover in increasing survival of red pine seedlings has been demonstrated at the Nicolet National Forest in Wisconsin (Lake States For. Exp. Sta., 1939). It is suggested that a partial cut be carried out under these circumstances, leaving a residual stand of red and jack pine, which should be sufficiently open to permit scarification.

To regenerate jack pine it is suggested that clear cutting followed by scarification and scattering of cone-bearing slash would be a suitable technique. Shade for the young seedlings would be provided by the scattered slash. This technique has previously proved encouraging in the Lake States, and in Manitoba and Saskatchewan (Ralston, 1951; Kabzems and Kirby, 1956; Cayford, 1958). As a third alternative a combination of the two previous suggestions may be attempted and the resulting stand should be a mixture of red and jack pine.

SUMMARY

In 1954 an experiment was initiated in southeastern Manitoba to determine whether scarification of the forest floor following the removal of merchantable jack pine trees in a mixed red pine-jack pine stand would be an effective technique for inducing pine regeneration on the cut-over areas. Annual examinations of

[7] A. B. Vincent, Petawawa Forest Experiment Station. Letter dated October 3, 1956.

regeneration were carried out between 1955 and 1958. Germination on scarified areas was much improved over unscarified areas but seedling survival on both scarified and unscarified areas was poor and the distribution and abundance of pine regeneration is presently unsatisfactory on both. It is suggested that seedling survival may be increased by providing shade either by increasing the residual crown cover or by scattering the cone-bearing jack pine slash, or by a combination of both.

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APPENDIX

Common and Botanical Names of Plants Mentioned in Text

Bearberry	*Arctostaphylos uva-ursi* (L.) Spreng.
Choke-cherry	*Prunus virginiana* L.
Mountain-rice	*Oryzopsis asperifolia* Michx.
Pine, jack	*Pinus banksiana* Lamb.
Pine, red	*Pinus resinosa* Ait.
Redroot	*Ceanothus ovatus* Desf.
Rose	*Rosa acicularis* Lindl.
Sand-cherry	*Prunus pumila* L.
Saskatoon	*Amelanchier alnifolia* Nutt.
Spike oat	*Helictotrichon hookeri* (Scribn.) Henr.
Spruce, white	*Picea glauca* (Moench) Voss
Strawberry	*Fragaria virginiana* Duchesne

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